The Impact of Environmental Constraints on Urban Design in Case of Mega Events

Case Study:

Summer Olympic Games

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Abstract. The aim of this research is to check the efficiency of put into practice 'green guidelines' in the field of mega-events. Case study of this research are Sumer Olympic Games, main issues are to find out the role of International Olympic Committee in 'greening' the Games that tend to promote sustainability approach as a development model for modern Games, and to find out which stakeholders play leading role in achieving eco-friendly Games. This research will use the comparative analysis of energy efficiency and carbon emissions calculations based on data collected about Barcelona 1992 and London 2012 Summer Olympic Games buildings.

Keywords: mega-events, Olympic Games, International Olympic Committee, environment, sustainability, energy, carbon emissions

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1. Mega-event – Spatial Specifications

Mega-event is an event of international scale, acting as intellectual and expert platform, within new approaches to the development of the strategic issues and scenarios of territory development, mechanisms of interest agreements and coordination of governmental activities, business communities and socium in purpose of increasing investment attractivity and competitiveness of the territory are proposed. [1] Mega-events, such as the Olympics or World-Expo are short term and high profile international events which have a long-term impact on host cities. Looking beyond the event itself, the mega-event strategy is basically one using this occasion as an engine for urban development. Today mega-event is considered as a tool of urban governance, a new approach trying to resolve the problems of the past to getting ready for future. [2]

1.1 Role of mega-events in "greening" the environment

One of the main problems that gains importance today is ecology. Attempts to reduce impacts of human activity on environment are urgently required. Governments of different countries all over the world try to unify their forces to solve the consequences that the age of technological and scientific progress as well as production growth left for us – environmental pollution, overuse of natural resources and etc., resulting in global warming, climate change and etc. Changes towards environmental improvements are becoming more politically acceptable globally, especially in developed countries. Society is slowly moving towards seeking more sustainable production methods, waste minimization, reduced air pollution from vehicles, distributed energy generation, conservation of native forests, and reduction of greenhouse gas emissions. [3]

One is witnesses of ecological summits and protocols of eco-friendly activities (such as Kyoto protocol 1997), creation of commissions and non-governmental organizations with international activities such as United Nations Environmental Program, Green Peace, WWF and etc. All these measures pursue the aim to promote and regulate the environmentally-friendly development, policies and technologies.

The World's "Green" campaign is using mega events that have a great influence not only on the host-country, but also serve as a model for future development, regeneration and progress. Mega-events are acting as an intellectual platform for new approaches and technologies, acting also as an advertisement tool.

Mega-events are big-scale events of international scale today serve as a model of 'green' development promotion and prove on practice that taken measures are efficient and can bring more benefits for the future development of the territory.

As Phillip Furrer, project manager of International Olympic Committee (further – IOC) describes hallmark events such as the Olympic Games as global businesses which benefit from intense media attention and should therefore be used as an opportunity to encourage innovations in the sphere of sustainable development and

advance the sustainability debate a step closer to actual implementation. The Games have the potential to inspire positive actions from governments, businesses, communities and individuals. They can leverage positive changes in traditional consumption modes and construction practices. [4]

1.2 Emergence of environmental aspects in Olympic Games

Case study of this research is Summer Olympic Games, which have transformed from sporting event of big scale to the mega event, that is used as an urban tool in last decades, and is interesting example of emergence of 'green' aspect in policy-making and urban planning. Environmental aspect is comparatively young, it emerged after long period of determining processes, analysis of impacts, criticism and observation of consequences of the past Olympics.

Since the mid-1990s, environmental considerations have been increasingly prominent in Olympic planning, with each Games expected to leave a sustainable legacy [5]. For the first time in history the environmental issues were considered in 1994 and environmental aspect became an important part of following the criteria for bidding cities to be qualified.

Next important date in the 'urban' history of the Olympic Games is 1996, when the Environmental Protection Paragraph was added to the Olympic Charter as the recognition of the environment and sustainable development by International Olympic Committee. "[The IOC's role with respect to the environment is:] to encourage and support a responsible concern for environmental issues, to promote sustainable development in sport and to require that the Olympic Games are held accordingly"[6].

In 1999, Agenda 21 was approved and adopted be the IOC Session. The Olympic Movement Agenda 21 established an action program that allowed members of the Olympic Movement to play an active part in promoting sustainable development, particularly in relation to sports activities. This document, prepared by the IOC Sport and Environment Commission, in close consultation with UNEP, lays out significant provisions for the active involvement of the global sports community in the protection and safeguarding of the environment. Particulare recommendations were given in the area of environmental sustainability such as the use of fewer non-renewable resources, the adoption of energy saving solutions, the use of fewer dangerous products and the release of fewer pollutants into the air, water and soil, as well as the need for an environmental impact assessment to be conducted before and after the event. Also, infrastructures created must be safe in terms of the quality and durability of materials and resistant to attack or natural disaster. The accommodation must be suitable for healthy living and allow economical use of natural resources. [7]

This importance of fore written became more obvious after Sydney Olympiad in 2000, when the city proved on practice the possibility of eco-friendly approach in cooperation with Green Peace. This not only helped Sydney to win the bidding contest to host the 2000 Games, but it had some very particulare effects on the organization of the Games. Environmentalists took an active part in the drafting of the "Environmental Guidelines" adopted by the organizing committee. [4] "Environment"

officially became a third pillar of Olympism after the two central – “sport” and “culture”. At the same time, referring to Philippe Furrer, “while such concerns for an environmentally friendly way of planning and organizing the Games have taken far more importance over recent years, it must be set against the danger of promoters and Games organizers using such mainstream “Green Games” notions for the sake of good reputation”. [4]

The IOC claims that its objective is “not only to see that staging of the Games do not have a negative impact on the environment, but also to help improve environment and leave a green legacy”. [7] [42] After Sydney, next city to host Games was Athens in 2004. Despite the fact that Greek authorities were affirming that "Olympic Games are a challenge as well as an opportunity for the broad implementation of programs and actions which are environmentally friendly and in accordance to the principles of sustainable development projects will be realized with the use of environmentally friendly technologies and materials, and this will be a prerequisite in all relevant tenders" [8], the city failed to perform these objectives, as Nikos Charalambides, the representative of Greenpeace Greece, has later reported: "This list of failures in the environmental performance of the Athens 2004 Olympic Games shows that when there is no strong political will, failures will override wins. Athens is well behind Sydney regarding the environmental performance of the Games. The distance from environmental excellence and sustainability is so big that Athens is disqualified from this race". [9] This confirms that green legacy is not the guarantee of success of taken measures.

Being the opposite to the Athens, Beijing has once more proved the efficiency of ecological approach of the Olympics (along with Sydney) – the report of UN on environment published on 25th of October 2007 (even before the start of the Games) notes the impressive “ecologization” of the games preparation for 2008: reducing CO2 emissions and air pollution, solar energy technologies implementation, eco-friendly buildings, waste water regeneration, and etc. [10]

Next step in the history are Summer Olympic Games in London, 2012, that claim to be ‘the greenest Games in the history of Olympics’. [11] Even on the bid-stage organizers were promoting green environment and sustainability and made them main goals of their bid, and after winning the competition started developing Olympic Village and sport venues considering different regulations starting from materials and biodiversity of the region. While the Organizing Committee of Olympic Games presents the project as zero or close-to-zero carbon producing, scientists and researches criticize the lack of other renewable energy sources but wind turbine and lack of cooperation between different stakeholders for achieving better results. [12] Despite different opinions about ‘environmental’ results of the games, at this stage it is hard to estimate the real ‘environmental’ results before the final reports and Ecological Footprints are published.

1.3 Olympic Movement, Environment and Sustainability

International Olympic Committee (IOC) clearly recognizes responsibility towards the promotion of Sustainable Development, and considers environment as an integral dimension of Olympism, alongside sport and culture. National Olympic Committees are encouraged to form partnerships with local government entities in order to implement specific environmental projects. [13] This change became more important in the last decades, and the promotion of environmentally-friendly and sustainable approach is seen as the main model of development.

In the context of Olympic Games "sustainable development" means according to the United Nation's definitions, development that is balanced between people's economic and social needs and the ability of the earth's resources and ecosystems to meet present and future needs. [14]

The IOC has a special responsibility to share in the implementation of this concept of sustainable development. Because of its universality and the global appeal of sport, the Olympic Movement has the ability to play an active part in promoting measures favoring sustainable development. This will imply changes in the nature of Olympic Games planning.

It must be acknowledged that fully integrated sustainability practices in the Games organization are at the earliest stages of a journey that will continue for many years. The need is now for well defined and broadly accepted sustainability performance indicators. Efforts have started in this area but must now be adapted and applied to the Olympic Games concept.

1.4 Arising issues

Mega-events always have arguable impact on the host-cities or host-countries that can act in both positive and negative way. Furrer, the project manager of International Committee writes that utopian as this may seem to some critics, the hosting of the Olympic Games can be conceived as an opportunity for positive changes and for a better quality of life in urban milieus. As the IOC President Jacques Rogge wrote recently, "The Olympic Games may not make the world a better place all the time, but the IOC will continue to strive to make the Olympic values grow stronger between Games, and thereby play its part in making the world a better place". [4]

Environmental aspects regarding mega events are now in the stage of evolution since the date of emergence few decades ago. Today they gained actuality and are considered as serious part of organization of events. Indeed it is only now that we reach a point at which the environment is being mainstreamed into the organization of mega sporting events. Sport institutions, teams and sponsoring organizations have recognized the need to better understand the environmental impacts of the activities they sponsor, host and regulate. [15] Concerning Olympic Games, Furrer argues that sustainable development strategies are still in the process of formation, and Olympic Movement has a big potential for advertising basic principles of sustainable

development: Olympic Games being mega-events of international scale attract intense media and international attention and therefore can be used as advertisement tool. [4] According to Mc. Kenzie's definition of sustainability approach (2006) it includes environmental approach as well as social and economic.

Environmental dimensions, being comparatively young in the field of mega-events, create some problems that are discussed recently. Collins describes the lack of balances framework - " … there is still some way to go towards an encompassing framework that fully explores the trade-offs between the achievement of economic, socio-cultural and environmental goals. There is also a strong desire on the part of institutions such as the IOC and FIFA to be seen as part of the solution and not part of the problem, for example, through the adoption of 'environmentally friendly' bidding and planning processes". [15] Inspired by the fact that environmental dimensions have weak effect on practice and trying to identify if the Games are really Green, N. Maslova in her master of science thesis describes another problem of vague requirements that still play the role of recommendations not regulations, at the same time "the lack of communication between Non-Government Organizations, which actually give environmental assessment of Olympic Games, and International Olympic Committee" takes place. Also she agrees with A. Collins regarding evaluation of performance and recommends enforce the cooperation between Non-Government Organizations and International Olympic Committee and create common system for evaluation of environmental performance, state more clear requirements for the ecological organization of Olympic Games and change focus from environment to sustainability. [16]

2. Methodology and Case study

2.1 Are IOC's environmental regulations effective?

After emergence of environmental constraints and limitations success of reached results remains undefined. Activities in 'green' policies of International Olympic Committee become more important within time, and require appropriate attention to prove their efficiency. As one can see from the history of past events, success achieved is not constant - some cities still manage to fail the Games in environmental field. [16] For example, Games in Athens 2004 failed to be environmentally-friendly and Games in Beijing 2008 showed good results, while critique was remains ambiguous.

This research tries to identify if the modern Olympic Games are more sustainable and green than Games that were held without green legacy, and to check the efficiency of regulations and recommendations of IOC in the field of environment. While the documentation and recommendations of different stakeholders promise to reach the target of fully-sustainable Games practice casts doubt on the effort measures. Public policy and organizational strategies are now adopting sustainable development principles quite widely but the challenge remains of translating the concept into practice. The Games are not only a great opportunity for host cities to face the global challenges of competitiveness and exhibit their best attributes, but they also provide host cities, regions and countries, as well as the IOC, with an opportunity to promote sustainable development. [4]

2.2 Methodology and environmental dimensions

Environmental dimensions – a big range of aspects that are regulated to prevent harm to the natural environment and minimize the impact of human activity. These aspects are issues that organization should take into consideration in their work, things that we care about due to individual human aspects (e.g. noise, smell) laws and regulation, etc. Environmental aspects on the other hand can also be a product's or production process's environmental impact, e.g. emissions to a nearby river and use of energy. [17]

Environmental regulations, rules and recommendations of IOC, NGOs (Non-Governmental Organizations) and local governments cover such dimensions as energy, transport, water management, waste management, carbon emissions, technologies and etc., and create framework within which the future development should be promoted (see Figure 1). Main targets are reducing carbon emissions, increasing use of renewable energy, use of recycled materials, efficient water and waste management, etc.

2.2.1 Analyzed dimensions

Dimensions studied in this research are limited to energy requirements/consumption and carbon emissions produced by the constructed for hosting Olympic Games housing and office buildings. The reason why these dimensions were chosen for research was long-lasting impact of these factors that lasts not only during construction period, like transport management and waste management of holding event and construction, but serves during all life period of the venue, as well as the most important factors influencing environment (covered dimensions can be seen in green in Table 1).

Figure 1. Example of environmental regulations by different organizations and analyzed dimensions

	Objects	IOC Specifications	Other Specifications
LONDON	Energy	- Proportion of energy from renewable sources - 20%	- Reduce energy use by 20%; 22% of energy - from renewable sources (EU Energy Efficiency Directive) - minimize energy use at all stages of development of the project; - replace fossil fuel energy sources with renewable; ban nuclear energy (GreenPeace)
	Buildings	- Include enrgy concerns in architectural plans, espesically thermal considerations - Avoid using toxic substances - Use environmentally-friendly materials and techniques	- Insulation, natural ventilation should be given preference - use of environmentally-friendly materials (GreenPeace)
	Carbon Emissions	- Reduce carbon emissions of the Olympic Park by 50%	- Reduce carbon emissions by 20% (EU Energy Efficiency Directive) - There should be no pollutant emissions to the air during construction or eco-lifecycle of the building or venue (GreenPeace)
	Transport	- 100% of visitors to use walking, cycling of public transport - 50% of materials for construction transported by water or rail	- Reduce need of private transportation - Establish non-fossil fuel based public transport - Ban fossil fuel based transportation vehicles for public and official access to the Olympic Games (Green Peace)
	Waste Management	- 90% of materials from construction must be recycled or reused - Minimize waste - Avoid useless construction	- ban burial of hazardous waste as part of any Olympic development - establish 100% closed-loop recycling systems (Green Peace)
	Water Management	- treat wastewater - protect water resources - satisfy the demand of sport event without endangering water supply of the region	- There should be no pollutant emissions to the water during construction or eco-lifecycle of the building or venue (GreenPeace)

2.2.2 Ways to improve energy efficiency and reduce carbon emissions

Technology and science offer numerous ways to improve energy efficiency and at the same time to minimize carbon emissions.

Efficient energy use, sometimes simply called energy efficiency, is the goal of efforts to reduce the amount of energy required to provide products and services. Improvements in energy efficiency are most often achieved by adopting a more efficient technology or production process. [18]

In renewable generation, efficiency is less of an issue for the simple reason that resources like wind and sunlight are essentially inexhaustible and free. A typical wind

turbine, for example, might achieve 45% efficiency in converting the physical force of the wind into electric power. [19]

For example insulation allows the building to use less energy for heating conserving the temperature for a longer time due to decreasing losses. Use of energy-efficient window systems can also contribute to the performance of building as a whole. Windows are thermal holes – an average home may lose 30% of its heat or air-conditioning energy. There are even some cases where new windows can be net energy gainers. [20] At the same time proper placement of windows and skylights as well as the use of architectural features that reflect light into a building can reduce the need for artificial lighting.

Location and surroundings also play role in regulating its temperature and illumination. For example, trees, landscaping, and hills can provide shade and block wind. In cooler climates, designing buildings with south-facing windows increases the amount of sun (ultimately heat energy) entering the building, minimizing energy use, by maximizing passive solar heating. Tight building design, including energy-efficient windows, well-sealed doors, and additional thermal insulation of walls, basement slabs, and foundations can reduce heat loss by 25 to 50 percent. Even such details as roof color can influence the efficiency: dark roofs may become up to 39 C° (70 F°) hotter than the most reflective white surfaces, and they transmit some of this additional heat inside the building. US Studies have shown that lightly colored roofs use 40 percent less energy for cooling than buildings with darker roofs. White roof systems save more energy in sunnier climates. [21]

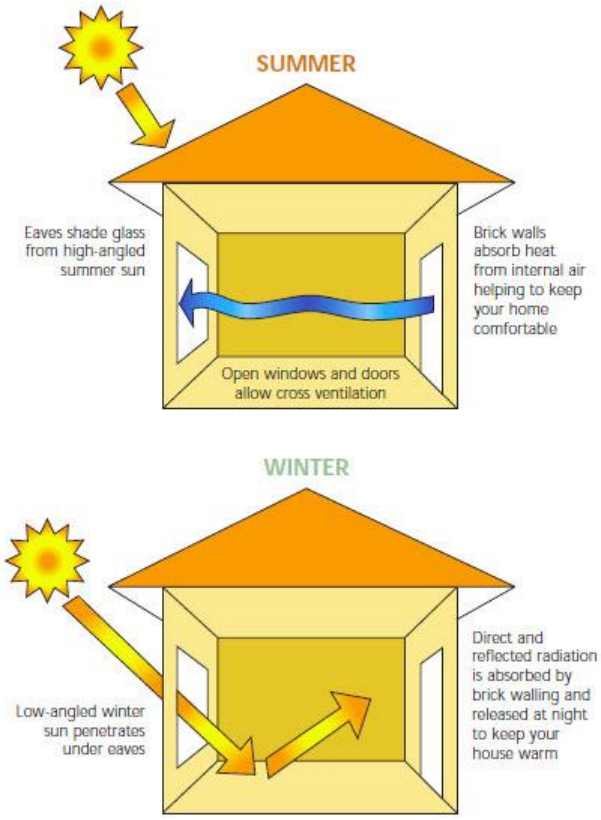
Improving energy efficiency has another benefit – reducing carbon emissions. They are directly dependent on the performance of the buildings, and as buildings consume 35% of world energy they are responsible for 35% of the world carbon emissions. [22]

According to the International Energy Agency, improved energy efficiency in buildings, industrial processes and transportation could reduce the world's energy needs in 2050 by one third, and help control global emissions of greenhouse gases. [23]

Carbon emissions of building sector are include construction emissions, transport emissions, but mainly depend on the energy performance of the building, mainly – occupant behavior and technologies and systems of the building. Minimal production of carbon dioxide can be reached with the simplest technologies and can be cost-efficient.

One of such technologies on the way to reduce energy consumption of the building as well as emissions is Passive House. It became publicly used since 1996, after Passiv-haus Institut was founded in Darmstadt, Germany, to promote and control standards. Passive design refers to use of simple design techniques that assist in controlling ventilation and the temperature of the building without use of any mechanical systems – proper site orientation, adequately sized and properly shaded operable windows, right insulation type for right climate conditions and etc. (see Picture 1) [24]

Figure 2. Passive house design principle



Preference of wall materials is given to heavy and dense materials, such as bricks, that absorb heat and slow down its transfer through the wall. This moderates temperature changes, slowing down heat gain in summer, and storing heat in winter. Lightweight walls made from fibro, weatherboard and corrugated iron have very low thermal mass when compared with brick walls (see Picture 2). [25] Buildings with higher thermal mass (and exterior insulation) have fluctuation of temperature during the day inside the building, thus providing less energy demand and economy (see Picture 3).

Figure 3. Thermal mass of different types of walls

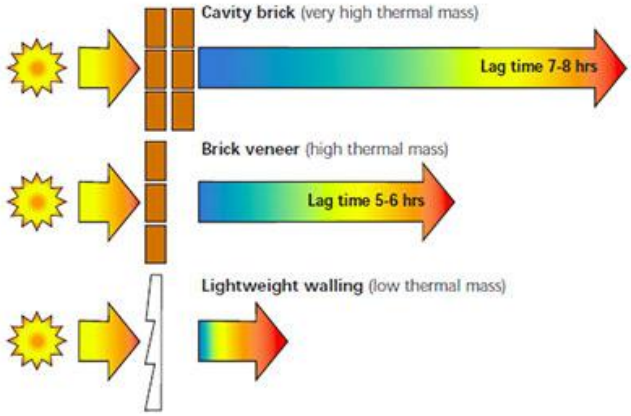
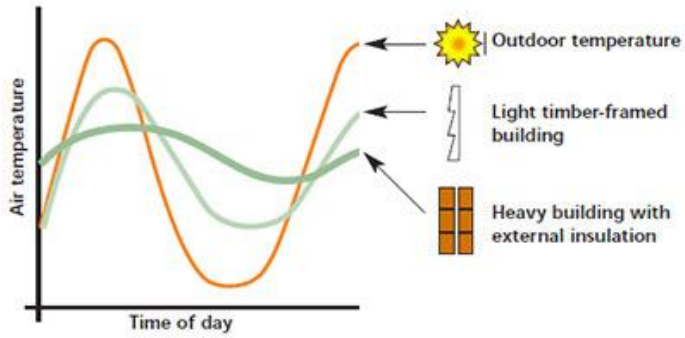


Figure 4. Thermal mass effect on temperature fluctuations



Source: Your Home, Technical Manual, sec 1.7, Australian Greenhouse Office

2.2.3 Parameters and inputs to evaluate energy consumption

Because of incomplete technical data, unavailability of building's drawings and information on insulation, materials used and energy/heating systems, the following hypotheses were used for simplification of simulation:

Barcelona	London
- gas heating systems are considered in building types - due to similar design and same construction period, all housing in Barcelona except Arts hotel and Mapfre Tower were considered as same type - inner insulation type due to technical structures of the buildings - standard glazing material	- renewable energy was considered in the calculations, that supposed to cover all energy needs of the buildings in Olympic Park, as according to the primordial concept - all buildings were randomly selected in equal proportion for differentiation between types - passive house technology is supposed to be used on the site, as well as energy-saving materials and glazing. Technical data on insulation and facades material was considered to be the same as in Vancouver Olympic Village, that also used passive house technologies in their design - facades of office buildings were calculated as aluminium with the same insulation type as described in Vancouver buildings details (see Appendix 1)

2.3 Case study

Two cases of Summer Olympic Games were chosen: Barcelona in 1992 and London in 2012. During both of them post-industrial area was cleaned up and transformed to the housing area and in case of London built up with sport venues. Despite the fact that Barcelona's construction was not under any limitations or regulations considering environmental aspect, it has made a big contribution to the regeneration of post-industrial area into the lively neighborhood and city attractions. At the same time upcoming Olympic Games in London claim by organizers for being "the greenest Olympics ever". Olympic Village in London is also located in post-industrial area and represents huge regeneration programme.

For each case 3 types of housing and 2 types of office buildings were analyzed to estimate energy requirements, consumption and carbon emissions.

2.3.1 Barcelona Summer Olympic Games 1992

Barcelona's Games are regarded as one of the most successful Olympics ever. Besides the fact that Barcelona's Olympic Games transformed the city to tourism center and brought huge economic benefits, great project of urban transformation and regeneration took place. The transformations made in the city for the Olympics have become regarded as a model for other cities wishing to initiate large-scale revitalization schemes. [26] [38] [39]

The former half-destroyed industrial area was regenerated and became one of the most attractive parts of the cities. Barcelona was opened to the sea with the construction of the Olympic Village and Olympic Port in Poblenou, a run down, post-industrial neighborhood. Various new centers were created, and modern sports facilities were built in the Olympic zones of Montjuïc, Diagonal, and Vall d'Hebron. The construction of ring roads around the city helped reduce the density of the traffic, and the El Prat airport was modernized and expanded as two new terminals were opened. New hotels were built and several old ones refurbished. [27]

Located just few meters from the beach, this 154-meters high tower was serving as housing for athletes during Olympic Games, and then was transformed to Arts hotel (Ritz-Carlton) in 1994. Design by Bruce Graham of Skidmore Owings Merrill Architects (SOM Architects). Perimeter structure is located outside the building and not covered by façade. Materials used on the façade are aluminum and colored green glass (see Figure 5a). Together with Arts Hotel, Mapfre tower (see Figure 5b) of the same height became symbols of Barcelona regeneration. First floors of the building are shopping malls; the rest is used for offices and occupied by Mapfre Insurance and other companies. Architects Inigo Ortiz and Enrique de Leon created façades in steel and reflecting glass that in create the illusion of mirror. Structure – particulare and steel.

The whole area of Villa Olimpica, except Mapfre Tower and Arts Holtel, is built up with 6-10 storey dwelling, mostly made in red bricks and classic materials (see Figure

5c). Buildings have different shape but made in the same technique and create atmosphere of unity all over the district. Among the buildings and inside courtyards are different buildings of public use such as policlinic, local authority office and office buildings.

Figure 5. Example of Barcelona's buildings

a) Arts Hotel

b) Mapfre Tower

c) Brick houses

d) Telephone Echange building

During the Olympics in Barcelona press centers, broadcast centers and other office facilities were located at the sporting venues and most of them did not have separate buildings. One of the examples is located among dwellings in Villa Olimpica and today is occupied by Telephone Echange Company (see Figure 5d). Built in 1989-1992 by Bach Arquitectes, it is composed by 2 buildings connected with each other by corridor on the 3rd floor. One of the buildings is rectangular with low glazing rates and grey bricks finishing, another has oval shape in plan and aluminum façade.

Figure 6. Analysis of building types – Barcelona

	Housing Type 1	Housing Type 2		Housing Type 3	Office Type 1	Office Type 2
		A	b			
Glazing Rates	25%	50%	32%	19.4%	29%	14.6%
Floors Area	53372	41616	10744	5523	1300	1950
Total Type Area	53372	41616	10744	159339	1300	1950
Volume	181800	150280	34918	18456	5460	8125
Façade Materials	Aluminum	Aluminum		Red bricks	Aluminum	Grey Bricks
Insulation Type	Inner Standard					

2.3.2 London Summer Olympic Games 2012

Organization of Games in London claimed that it would be a new chapter in environmentally friendly Games – 'the greenest Olympics ever". [40] Like the other four bidders for the same Games, London made environment and sustainable development a major element of its bid and a particular environment project the centerpiece of the program. The main goal was regeneration of one of the capital's most underdeveloped areas, the Lea valley, by restoring an eco-system and by revitalizing an entire community, transforming this area into one of the largest urban parks created in Europe, stretching more than 20 miles. [28]The use of eco-friendly materials, efficient water and waste management, recycled materials and eco-friendly technologies was one of the main benefits.

For reaching these objectives, according to the FACTSHEET "The Environment and Sustainable Development" published in 2009 by IOC London 2012 Organizing Committee (LOCOG), building upon the commitments set out in its candidature file, has produced the London 2012 Sustainability Plan. The Plan is a framework for how LOCOG and its partners will address sustainability, and reflects the Organizing Committee's ambition to deliver truly sustainable Olympic Games.

The Plan is structured according to five priority themes: Climate change, Waste, Biodiversity, Inclusion, Healthy living. [13]

London's hosting of the Olympic Games indeed showcases Britain's firm commitment to contribute to the global solutions to mitigate the impact of climate change by cutting its carbon emissions to 50 percent of 1990 levels by 2025. [29] Chairman of the London 2012 organizing committee, Lord Coe: "We intend to set the very highest standards in sustainability and legacy for other games to follow."

At the same time London Assembly Green party member Darren Johnson expressed disappointment that the plans did not go far enough and that only 20% of the energy used at the games would come from renewable sources. "The government has a target for making all new homes carbon-neutral by 2016, but if we can't get a showpiece

development like the Olympic village right by 2012 there is not a lot of hope for 2016." [30]

Brownfield site of Olympic Village in London was Stratford district, post-industrial area with some dwelling that was demolished for the new project of urban park with improved infrastructure and world-class sporting facilities. It is designed by EDAW Consortium together with WS Atkins and Arup, as well as other architectural companies that were invited to create design of 60 housing units. (see Figure 7)

Figure 7. Housing in Olympic Village, Stratford

Buildings for athletes in Stratford city will be transformed to 3.600 new apartments for Londoners. Territory of Olympic Village is built up with dwellings of 9-11 floors height arranged as courtyards. All buildings have exterior insulation of roxul clayrock with 125mm thickness, 2 air openings on both sides. [41] All materials are eco-friendly, and 80% of their ingredients is made of recycled waste materials from the site:

- Type 1, buildings of 10 floors with facades decorated with cementous panels with ancient bareliefs of different types sport.
- Type 2, buildings 9 floor height. According to the technical drawings, the façade is finished with lining boards.
- Type 3, buildings of 11 floor height are finished with cement panels of 1 cm thickness.

International Broadcast Center (IBC) and Main Press Center (MPC) are one of the numerous huge builds on the site. The buildings were designed by Allies and Morrison, and RPS. (see Figure 8)

The whole area will be transformed to Business Park after the Games and supposed to provide job opportunities for London in future.

The IBC includes around 52,000 sq. m. of studio space over two double-storey floors with a temporary gantry running along the 275 m. long, 104 m. wide building for technical equipment. It has 8,000 sq. m. of offices over five floors at the front of the

building. The project is flexible and can be separated into a number of units and for design features to be altered such as cladding replaced with windows after event.

Figure 8. IBC in Olympic Village, Stratford

Olympic Delivery Authority is not satisfied with results of this construction, claiming that "it is simply not good enough as currently proposed" and instead of creating "vibrant new future" represents the buildings of past era but at a larger scale. [31]

Figure 9. Analysis of building types – London

	Housing Type 1	Housing Type 2	Housing Type 3	Office Type 1	Office Type 2	
					a	b
Glazing Rates	29%	28.5%	40%	2%	35%	62.9%
Floors Area	11056	5472	3980	143000	17920	9026
Total Type Area	110560	107190	102800	143000	66996	25295
Volume	34540	16900	13134	600600	71680	72208
Façade Materials	Cementous panels	Wood	Cementous panels	Aluminum	Aluminium	
Insulation Type	Exterior					

2.3.3. Regulations and directives

Regulations and directives for London Olympic Village according to energy and emissions are the main way to achieve the objectives claimed by organizers. They are addressed from different organizations, the most important of them – International Olympic Committee, European Union and Green Peace will be reviewed in this research.

Olympic regulations are published in "Manual on Sport and Environment" by IOC and in "Olympic Movement's Agenda 21" by IOC Sport and Environment Commission. Directives published by IOC mostly have non-obligatory character, they are mostly generalized recommendations. [37] One of the directives that is described precisely by Olympic Delivery Authority is 20% of energy must come from renewable sources. Recommendations are following:

- use renewable energy in proportion not less than 20%
- reduce energy consumption where it is used excessively
- promote the use of new technologies, equipment, facilities and practices which encourage the use of renewable energy sources and energy savings
- encourage access to renewable and non-polluting energy sources for areas without such power supplies
- include energy concerns in architectural plans, especially thermal considerations
- use environmentally-friendly materials
- avoid using toxic substances
- reduce carbon emissions of Olympic Park by 50%

United Kingdom, conforming to the European Union Energy policies, is obliged to follow Energy Performance Directive of the European Union and Kyoto Protocol limitations after signing up the agreement. Main regulation according to the Olympic village is the same proposed by Olympic Delivery Authority – 20 % of energy should be from renewable sources. [35] [36]

Regarding carbon emissions, government's Energy Review Report 2006 defines long-term goals for energy program. Main targets are:

- reduce emissions on 60% by 2050 with visible progress in 2020
- improve distributed energy generation including low-carbon heat
- use community based systems, including combined heat and power (CHP)

Homes in Olympic Village will be build according to the Code for sustainable homes Level 4 Standard, that means 44% lower carbon emissions comparing to 2006 Building Standards Target Emission Rates. [44]

After success achieved in environmental progress during Sydney's Summer Olympic Games 2000 preparation with strong cooperation with Green Peace, the organization published a set of environmental guidelines – "Greenpeace's Olympic Environmental Guidelines: A Guide to Sustainable Events" to continue active environmental practice. These new guidelines address key environmental issues the Olympic movement ant its

corporate sponsors need to follow if the environment is really considered as the third pillar of Olympism. According energy and carbon emissions guidelines are as following:

- minimize energy use at all stages of the development of the project
- replace fossil fuel energy sources with renewable, ban nuclear energy
- emit zero pollutants to the air during construction or eco-lifecycle of the building or venue
- use insulation and natural ventilation
- use environmentally-friendly materials.

2.3.4 Energy systems of Olympic Village

20% proportion of energy to be used on the Park that will be from renewable sources. The source of renewable energy will be 130 m. height wind turbine located on the north of the site.

The purpose of the turbine is to provide 4 million kWh per year to provide power to around one thousand homes (including Olympic Village). The turbine was designed to provide a great landmark for Olympic sustainability, including the ability to meet their bid commitment of 20% of energy for the Games to be delivered from sustainable sources.

Two energy centers were built to provide energy for Olympic Park during and after the Games. First energy center is one of the largest combined cooling, heating and power generating facilities built in UK, and located on the west side of the Olympic Park. This plant was built in the historic Kings Yard industrial buildings. It has a flexible modular design with a natural gas-fired combined cooling heat and power (CCHP) unit and bio-mass fired boilers, equipped with two 20MW hot water boilers, three 3.5MW bio-boilers, two 7MW electric chillers and one 4MW absorption chiller, as well as five cooling towers. [43]

Boilers of the energy center use natural gas as feedstock. Base demand for heat during winters is met through the bio-boilers that use sustainable biomass, such as woodchips and pulp, as feedstock.

Second energy center was built in the Stratford City. It will also serve the heating, cooling and electricity requirements of the Games venues and other facilities.

The plants are use energy systems and mechanisms to reduce the heat supply costs. Ammonia-based chillers and electrical and absorption chillers enable the Olympic Park to meet the demand for cooling. The distribution network consists of about 100km of new local electrical cabling connecting both the energy centers with the Olympic Park and the Stratford City developments.

The energy centers are proposed to reduce about 1,000 tones of carbon emissions per year with whose boilers and CCHP units operating in conjunction will. The CCHP utilizes wastewater treated at the site to cool the facility. The energy center plays a crucial role in meeting the ODA's target to reduce carbon emissions of the Olympic Park by 50%. [32] [33] [34]

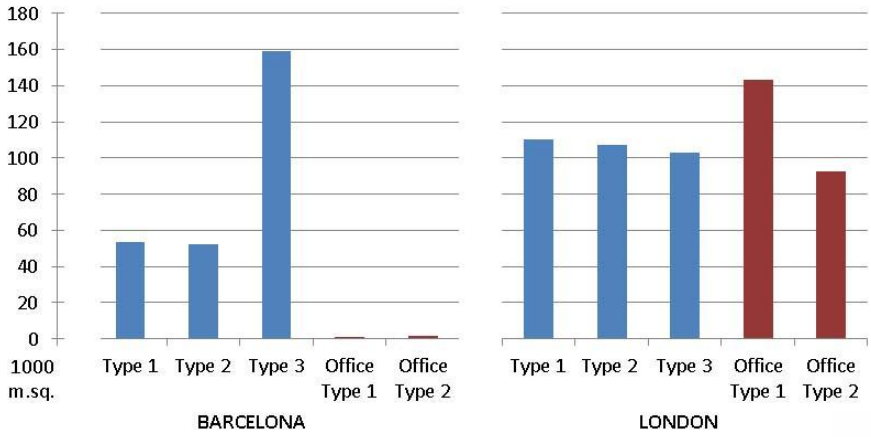
3. Results

Analysis of performance of the buildings per square meter, per type, total for each case of Games and per athlete provides full-fledged data for evaluation of environmental performance of Summer Olympics in Barcelona and London.

3.1 Performance of the buildings

More than 60% of the total area in Barcelona, approximately 160.000 m. sq. is represented by Type 3 (see Figure 10). Thus energy requirements and emissions of this type will have highest influence on the final results. Both Office Types in Barcelona have area of less than 2000 m. sq., the reason of it is that media centers, offices and other facilities were deconcentrated and included in the plan of sport venues or local buildings. Housing types in London have approximately equal proportions, around 105.000 m. sq. for each type, and total part of housing area is a bit less than 60%. The reason of high office buildings percentage comparing to Barcelona is IBC and MPC's construction in London that supposed to carry out local needs and create jobs after the Games, total area of both of them is more than 230 000 sq. m. (for master plans refer to Appendix 3).

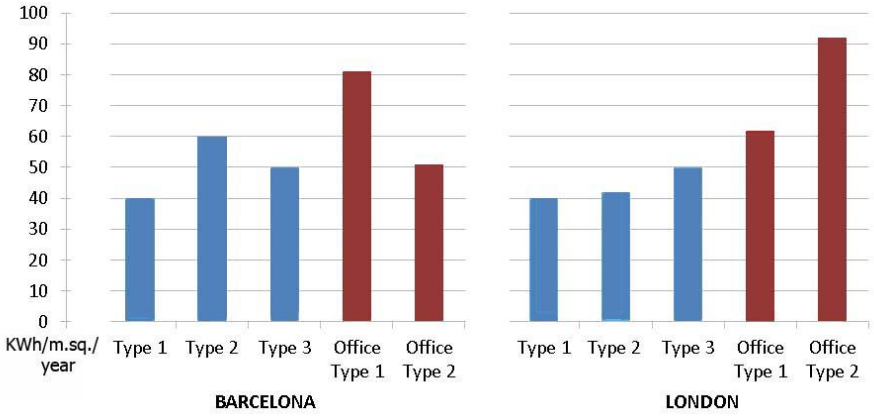
Figure 10. Total area per type of building



As one can see from the Figure 11, all housing types, Barcelona as well as London, have similar energy requirements per m. sq. per year around 45 KWh. Average requirements for office types for Barcelona is 66 KWh, for London – 77, the difference is not significant. Main factors influencing energy requirements are envelope types and climate. Barcelona has milder climate comparing to London, and degree hours heating that describe the amount of temperature that should be heated in the building to reach normal temperature around the year, in this case – 21C°, is 74,568 C°*h per year for London and 45,756 C°*h per year for Barcelona (see Appendix 2). This means that if to consider the same building in Barcelona and

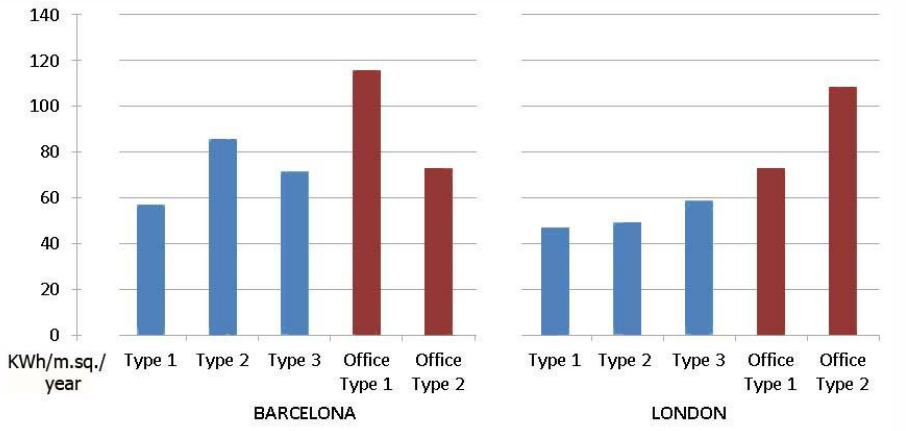
London, Barcelona's building will require less energy than the one in London. In case of London we also should not negotiate exterior walls insulation systems that allow building to act as one thermal mechanism and avoid unnecessary energy losses.

Figure 11. Energy requirements per m. sq. per year



Final consumption is characterized mainly by the yield of system. As one can see on Figure 12, consumption is linear depended on efficiency and inversely proportional to the yield that characterizes energy system. London buildings' consumption is 21% more efficient than in Barcelona's due to the yield factor, that is higher for London (0,85) owing to energy center that uses biomass as basic source, while Barcelona's heating system is considered as gas system, that is characterized by 0.7 yield factor.

Figure 12. Final energy consumption per m. sq. per year

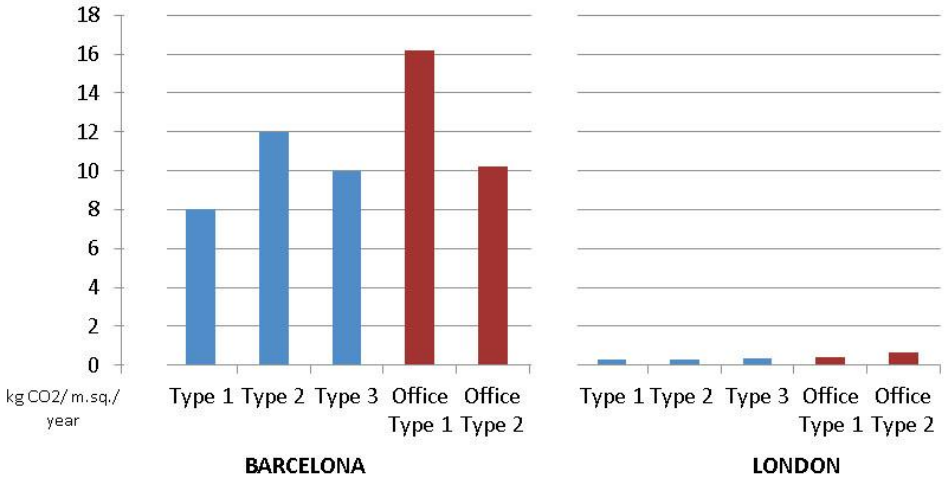


Opposite to final consumption, carbon emissions are linear proportional to the sources used by the system. Referring to Figure 13, according to CO2 emissions per square meter of each analyzed type, emissions of London buildings are considerably lower than Barcelona's, average 0.4 kg per sq. m. Renewable energy from the wind

produces 0.007 kg CO2/kWh, that is more than 25 times lower than emission factor for Spain – 0,2 kg. Spanish emission factor is the combination of different energy sources used in the country to produce kWh – gas, nuclear, oil, coal and renewables.

Spanish housing types have similar emissions around 10 kg per sq. m. Highest emissions per square meter are produced by office type 1 due to high consumption.

Figure 13. Kg CO2 emissions per m. sq. per year

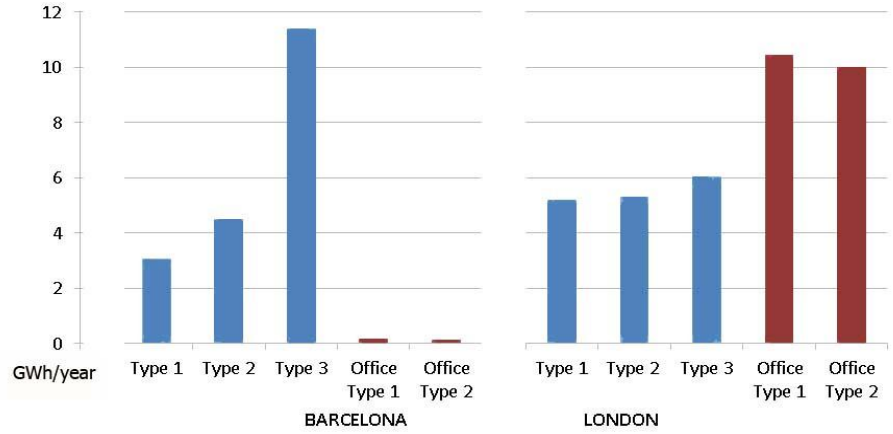


3.2 Analysis per type of building

Barcelona housing type 3 has the highest consumption among all analyzed types (see Figure 14) – more than 11 GWh per year. Such consumption is characterized by the major proportion of this type in the project: the whole area is around 159000 sq. m. Spanish office types show the lowest consumption – total less than 0,3 GWh per year due to the smallest area – 3250 sq. m.

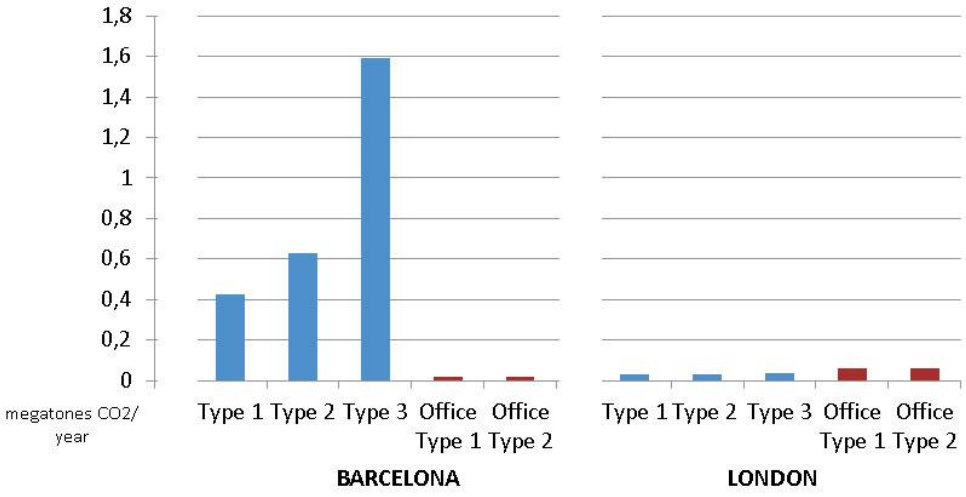
London housing types show equal consumption levels due to similar proportion of each type around 5,5 GWh per year, and office types have highest results in this section – both consuming approximately 10 GWh, that means more than 55% of total consumption of Olympic Park.

Figure 14. Final consumption per type of building per year



As seen in Figure 15 carbon emissions per type in London are very low – around 0,04 megatones for each type. Low similar emissions are produced by Spanish office buildings, but with area that is 100 times smaller. Highest emissions belong to Type 3 in Barcelona, that is biggest area and is responsible for more than 1,5 megatones per year, 60% of total emissions. Same proportion one can see in Figure 10 describing area per each type.

Figure 15. Carbon emissions per type of building per year

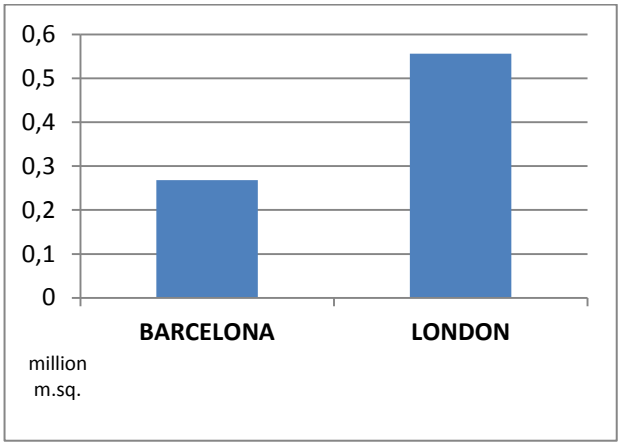


3.3 Comparative analysis

Comparative analysis shows the complete evaluation of environmental performance of the Games, which uses different approaches of evaluation and can fully represent general results of efficiency.

Total area built in London Olympic Village is 555 000 sq.m., in Vila Olimpica in Barcelona – 268 000 (see Figure 16). London's project is twice bigger than Barcelona's. London's office buildings play role in such difference. If we consider only housing types, London's project will be only 20% bigger than Barcelona's.

Figure 16. Total area



Same proportions are shown in Figures 17 and 18, which describe total energy requirements and final consumption for each case of Games. Barcelona's final consumption is 19.2 GWh per year, while for London it is 36,9 GWh per year.

Figure 17. Total energy requirements

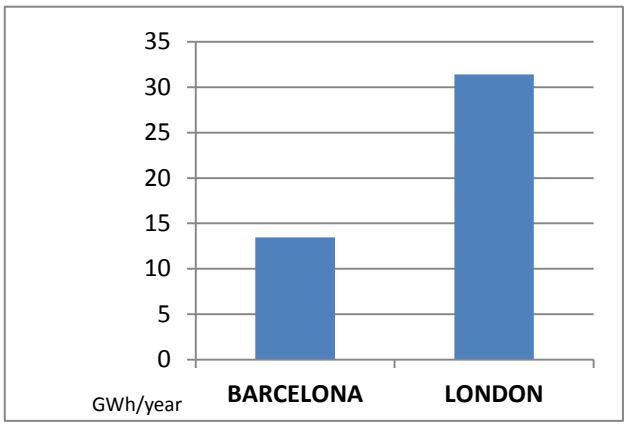
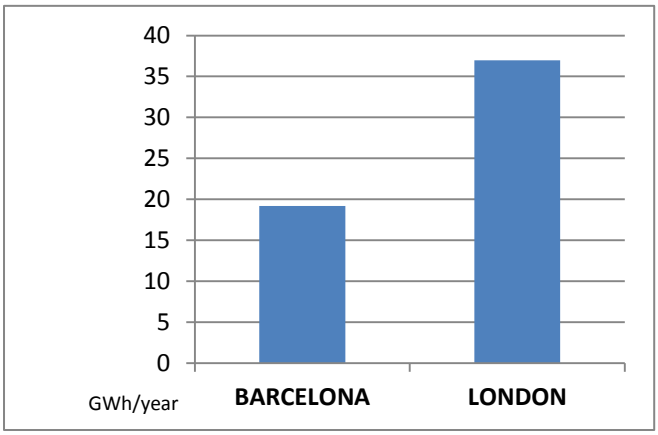


Figure 18. Total energy consumption



Being opposite to requirements and consumption, total carbon emissions of Barcelona are more than 15 times higher than London's (see Figure 19). In spite having smaller total area, Barcelona's gas system produces huge amount of emissions – more than 3.8 megatones per year, while London, which area is twice bigger than Barcelona's area, produces 0.25 megatones per year. This result was achieved by the use of renewable sources that according to the project covers all needs of Olympic Village housing.

Figure 19. Total carbon emissions

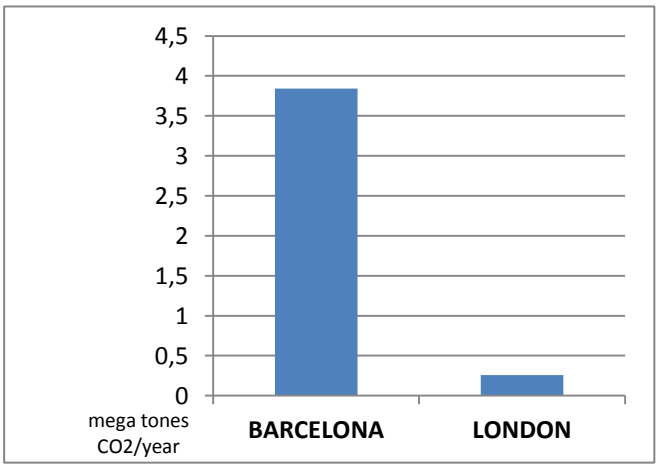


Figure 20 shows energy consumption per athlete per year. Consumption of athletes in London is 12 % higher than in Barcelona – more than 2,3 MWh/year. Total number of athletes in Barcelona was 9,350 and in London – 16,000. Such performance per athlete on London can also be explained by office buildings that were included in the calculation as a part of service provided to inhabitant. The role of office types in case of Barcelona was insignificant even in case that Type 1 had the highest consumption performance, in total representing 1,2% of total area in Barcelona.

Figure 20. Consumption per athlete (including all types)

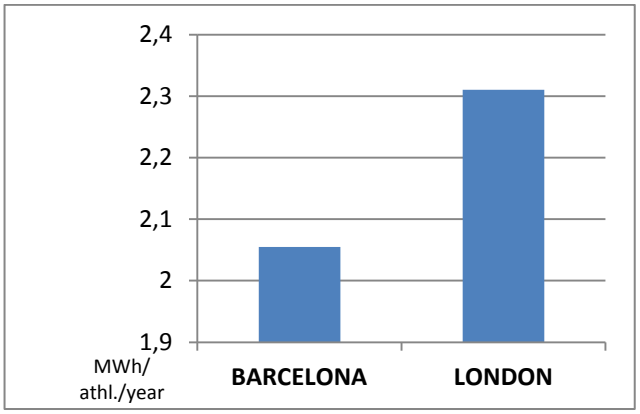
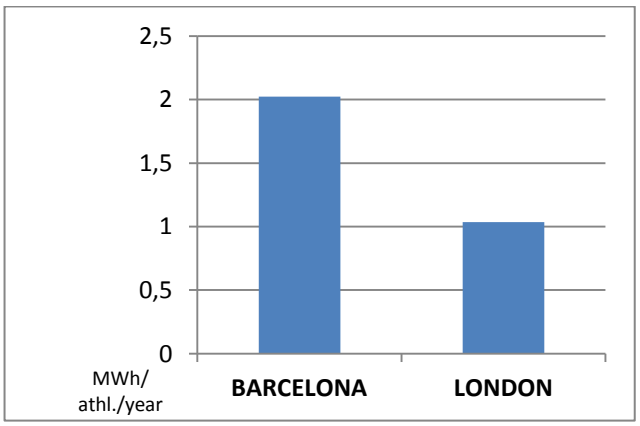


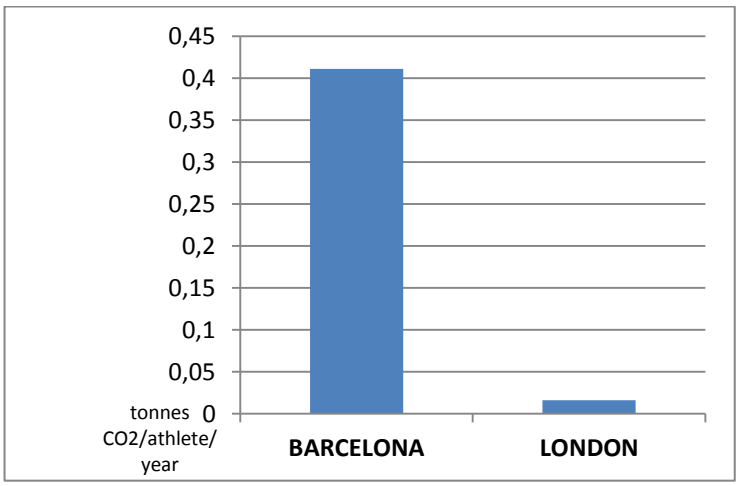
Figure 21 shows that considering only housing for evaluation of consumption per athlete oppositely changes the results: athlete in Barcelona will consume twice more energy than in London. The reason of such proportion is that area per athlete in Barcelona is 28 sq. m. comparing to London's 20 sq. m., and average energy consumption per square meter only for housing types is also higher in Barcelona – 71 kWh/sq.m./year – that is 40% higher than London's housing average performance of 51 kWh/sq.m./year.

Figure 21. Consumption per athlete (including only housing types)



Carbon emissions (Figure 22) per athlete represent the weakness of system in Spain concerning carbon emissions: Barcelona's athlete will be responsible for 0.41 tones on carbon emissions per year, that is more than 25 times higher than amount of emission for Londoner – only 1.6 kg of emissions. These results are proportional to the average performance of buildings regarding CO2 emissions.

Figure 22. Emissions per athlete



Conclusion

Analyzed dimensions - energy efficiency and carbon emissions – confirm that 'green' guidelines applied in London Olympic Village show good results: hundred times less emissions comparing to the emissions produced in Barcelona. At the same time energy consumption of the buildings remains almost the same. Carried out analysis certainly has errors and limitations – lack of technical data, detailed information on energy systems and production types. But even considering calculations error of 30% the results for London are still better than for Barcelona. Only error of 100% can dramatically change the results of both – energy and emissions, in both cases difference between cities is 100% of the lowest indicator.

Calculation of dimensions relative to the number of athletes shows us two kinds of results:

1. energy consumption per square meters indicators are almost the same, but if we calculate the consumption per athlete the results are ambiguous – consumption per athlete in London is 12% higher than in Barcelona,

2. at the same time if we consider only housing types – consumption per athlete in Barcelona is twice higher than in London.

One of the reasons can be climate, another – too high percentage of office buildings that have relatively high consumption comparing to housing types. At the same time higher consumption per person in Barcelona describing only housing types can be due to amount of athletes, that can't show the actual data per user after the Games, because in both cases housing for athletes is transformed for public dwelling and number of users remains unknown. These conclusions raise issues and create gaps in the way we analyze the performance of the buildings, and can be seen as a part of the problem of performance and efficiency estimation.

We should not negotiate that time break between construction of the buildings for Olympics in selected cases is 20 years: London Olympic Village was built according to the energy saving technologies while buildings in Barcelona were built according to standard techniques and materials. We also should not negotiate climate conditions. Even after fore-written, conclusions can still confirm the fact that London's consumption of the buildings still remains higher, but produced emissions (in all cases: per athlete, per square meter of the building and total) remain hundred times less (because of biomass).

Concerning the role of Olympic Movement the research can confirm problem of "vague requirements" [16] in the published guidelines proposed in the way of recommendations but not the rules. Research affirms the success achieved in better performance regarding carbon emissions is due to the role of local directives of British Carbon Emission Reduction Plan and local stakeholders that put the target to act according to higher standards than current ones, and of the directives of European Union regarding energy that tend to promote the use of renewable energy. Olympic

Committee duplicates the regulations of international documents (for example the proportion of renewable energy).

Unwillingness of Olympic Committee to actively participate in the sustainable development on practice and to become more politicized [16] by creating 'green' framework of actions that can affect other stakeholders keeps the level of achieved results much lower than real potential – instead of following already existing rules Olympic Committee could raise the standards and be more strict on their actual implementation, thus inspiring governments, communities, organizations [4] and people to step on the way of higher environmental standards and sustainable development.

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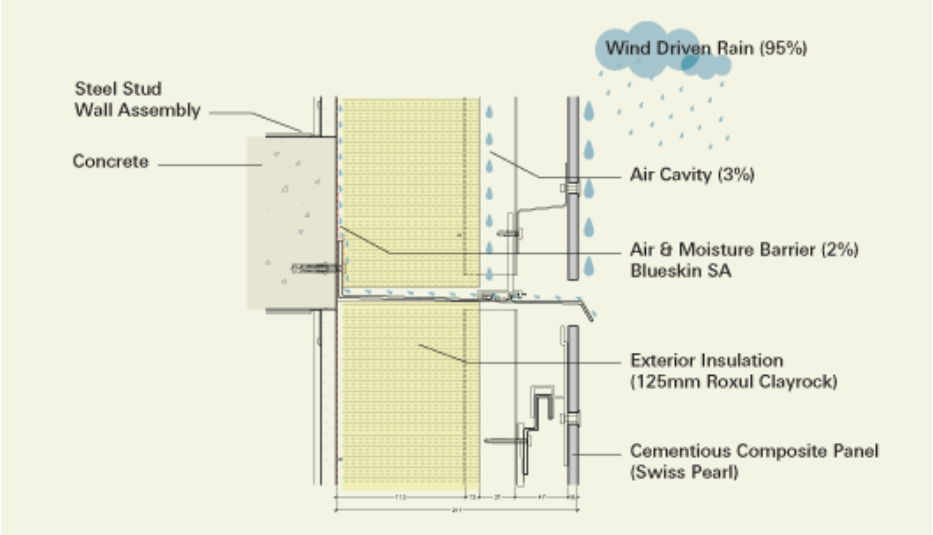
Figure 5 a – wikiarquitectura.com
Figure 5 b – Borkur Sigurjonsson, wikiarquitectura.com
Figure 5 c – Pedro Kok, flickriver.com
Figure 5 d – Bach Arquitectes, bacharquitectes.com
Figures 7, 8 – Olympic Delivery Authority, london2012.com

Appendix 1

Insulation details for passive house (Vancouver)



Appendix 2

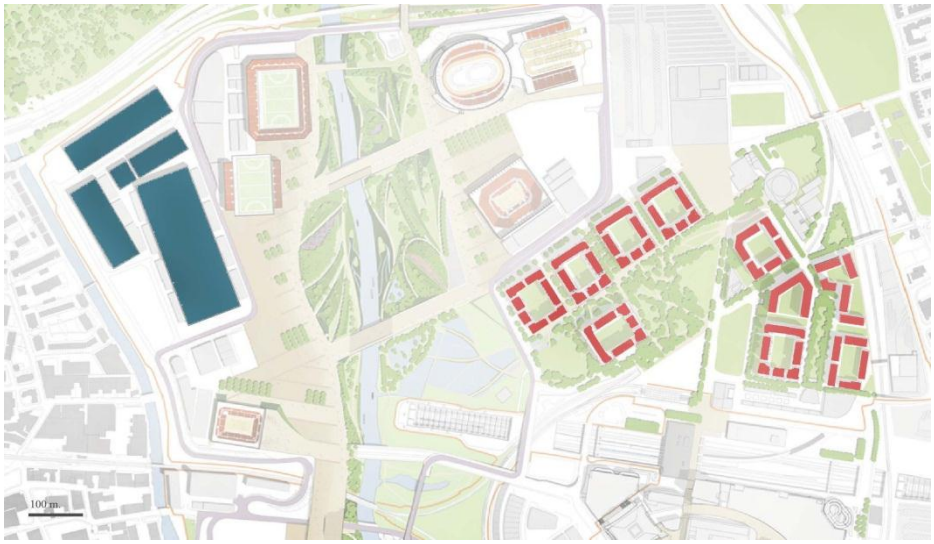
Degree hours heating for Barcelona and London for comfort temperature 21°C (Data source – worldweatheronline.com)

	Barcelona			London		
Temperature	Max.	Min.	Average	Max.	Min.	Average
January	14	5	9.5	9	5	7
February	15	6	10.5	10	5	7.5
March	17	8	12.5	12	6	9
April	18	10	14	15	7	11
May	22	13	17.5	18	10	14
June	25	17	21	21	13	17
July	28	20	24	23	15	19
August	29	21	25	23	15	19
September	26	17	21.5	20	13	16.5
October	22	14	18	16	10	13
November	17	9	13	12	7	9.5
December	14	6	10	9	5	7
DHH	45 756			74 568		

Appendix 3
Master plan Barcelona

Housing is highlighted with red, office buildings with blue color.

Master plan London



Housing is highlighted with red, office buildings with blue color.